Lecture Note: Firm Specific Human Capital

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1 Agenda

We've so far discussed general human capital, but 'specific capital' figures prominently in Becker's original Human Capital theory and in empirical and theoretical work on this topic. It's trivial to add specific capital to our stylized model, and we'll do this in a moment. But whether specific capital truly exists and whether it's important component of wage determination is still a subject of debate. This lecture will explore the theory and empirics of specific capital. The agenda is:

1. Adding specific capital to our two period training model.
   - A general stochastic approach
   - A contracting and observability approach: Specific capital is a bilateral holdup problem
2. Empirical evidence on the importance of specific capital.
   - Non-experimental approaches
   - Quasi-experimental evidence
3. Specific capital as general capital – a market thickness interpretation (Lazaer, 2003, NBER Working Paper)

2 Adding specific capital to the two period training model

- In our stylized model two period, it's easy to add specific capital to the equation.
- If we rewrote our productivity and outside wage functions, $f(\cdot)$ and $\nu(\cdot)$, each with two arguments, g, and s for general and specific training, we would have the following:

$$\begin{aligned} y &= f(g,s) \text{ with } f_1(g,s) > 0 \text{ and } f_2(g,s) > 0, \\ w &= \nu(g,s) \text{ with } \nu_1(g,s) > 0 \text{ and } \nu_2(g,s) = 0. \end{aligned}$$

  Since specific capital in its canonical form has only one buyer, the outside wage *cannot* rise with specific capital accumulation.

- Does this mean that the worker's wage will not rise with specific capital accumulation? Clearly, there is a contracting problem here. Specific capital investment generates a flow of quasi-rents, and it's not clear to whom they should accrue. If either party severs the relationship, both lose the flow of rents. So, this is typically a case where some form of Nash Bargaining seems plausible.

- Here's one way to think about it: Worker departures are stochastic – determined in part by exogenous shocks that increase the worker's outside opportunity. Examples might include (idiosyncratic) wage offers, life events, spousal job opportunities, etc. The higher the wage the worker receives relative to their outside opportunity, the lower the likelihood that the worker will leave in response to an exogenous shock. Since the firm earns quasi-rents on the workers specific capital, which are lost if the worker leaves, the firm may find it optimal to share some of these rents with the worker.

- More specifically, write the PDF of the worker's exogenous shock function as $h(z)$ where z represents the monetized value of outside opportunities that arise randomly in period 2. Workers depart in period 2 if they receive a shock z that exceeds their wage w. Now, the firm's maximization problem for wages – taking specific capital as given for convenience and ignoring general capital – becomes

$$\max_{w} \ (\pi|s) = H(w)[f(s) - w],$$

where $H(\cdot)$ is the CDF of z. So, if the firm paid $w = z^{\max}$, no worker would ever quit. The FOC becomes

$$h(w^*)[f(s) - w^*] - H(w^*) = 0.$$

It's clear that even though $v_2(g, s) = 0$, the firm will optimally choose $w^* > 0$, which implies that $\partial w / \partial s > 0$.

- So, it's not hard to generate the implication that wages *should* rise with specific capital investment. But this leaves two questions unanswered:

  1. Is such specific capital investment occurring?

2. Do these investments raise wages in practice as theory suggests they might?

- Truth be told, we'll never answer the first question. But if we could prove that job tenure *causes* wages to rise, we might take this as evidence that specific capital investment is occurring.

- How do we test this? We'll come to that in a minute

2.1 A contracting approach: Prendergast (1993, QJE)

- If you believe in the idea of specific capital, there is a hold up problem, and it's worse than in the case of general human capital. As Prendergast, points out, this is a 'dual hold up problem:'

  - The firm has an incentive to renege on any wage commitment once the worker has sunk a specific capital investment.
  - Recognizing this, the worker has an incentive not to obtain these skills in the first place.
  - (Note the assumption is that the worker bears the psychic cost.)
  - So again, contracting problems and skills investments decisions are linked.

- This problem is severe in the case of specific capital because specific capital is arguably 'observable' but not 'verifiable.' That is, a firm and a worker can plausibly observe whether a worker has obtained specific capital, but a court could not verify this information.

- So we must consider the set of contracts that are self-enforcing, that is, where commitments are enforced by subgame perfect mechanisms after training investments sunk.

- The details of this model are quite straightforward. I'll just sketch the simplest version given in the intro of the paper:

  1. A risk neutral worker with reservation utility r is employed in a risk neutral firm for a single period.

2. r must be earned in expectation in both periods.

3. Worker can be assigned to one of two jobs, Easy or Difficult: D or E.

4. Before job assignment, a worker can acquire specific skills $s = \{0, 1\}$.

5. Worker utility is $U = w - sc$, where w is the wage and c is the psychic cost of acquiring specific skills.

- Will the firm be able to induce the worker to acquire s?
  - If the firm promises a higher wage conditional on skill acquisition, is promise credible?
  - If the worker committed to acquire skills in exchange for up front payment in 1st period, is this committment credible?
  - So, there is no simple feasible contract here, even if skills acquisition is efficient.

- Now, assume that the firm *can* commit to wages as a function of job tasks (D or E). Why is this commitment credible? Presumably, actual job assignment/tasks are verifiable by a third party, although specific capital is not.

- We need a key assumption now: task D is differentially sensitive to specific capital investment s. More restrictively, let $y_i(s)$ be output as a function of job assignment and specific skill. We want

$$y_D(0) < y_E(0) < y_E(1) < y_D(1).$$

  This implies that:

  1. Training is productive in both jobs (actually, this is not necessary – in fact, it makes the problem less likely to have a solution.)

  2. Efficient assignment requires that trained workers go to job D.

- Assuming firms can commit to a wage schedule associated with job assignment, then they will promote workers iff:

$$y_D(1) - w_D \geq y_E(1) - w_E,$$

and workers will train if

$$w_D - w_E \geq c.$$

Putting these together, the two-sided holdup is solved if $y_D(1) - y_E(1) \geq w_D - w_E \geq c$.

- Note a nice subtlety. If training is efficient, this implies that $y_D(1) - y_D(0) \geq c$. But this does not imply that $y_D(1) - y_D(1) \geq c$. In other words, once the worker is trained, it's not clear that the firm would be willing to reimburse her the cost of training in exchange for doing the more difficult job.

- Hence, there is still a strong incentive for appropriation, and this tendency constrains the set of feasible contracts. It's plausible that no specific capital investment will occur in equilibrium, even if this investment is efficient. I don't think there is any case in this setup where specific capital investment will occur where it should *not*.

- The rest of the paper formalizes this set of insights.

- What is useful here?

  1. Useful exposition of the two-sided hold up problem; shows that it will probably not have a solution that is both efficient and feasible.

  2. Endogenizes the idea of 'a job.' Economists have little to say about why job titles exist and why wages are attached to them directly (see Baker, Gibbs and Holmstrom, QJE, 1994). This paper provides one possible explanation for why firms would use this policy. See Gibbons and Waldman, QJE, 1999, for a rich elaboration of related ideas.

  3. Also shows when the necessary conditions are unlikely to be met. Titles cannot be purely nominal in this model; firm must directly benefit from assignment of workers to new tasks (why?). This model would not be relevant in a setting where every worker at a firm did the same job (academics, lawyers). In this case, specific capital investment must occur (if at all) for alternative reasons (e.g., up or out contracts).

- Can the Prendergast model be linked to our omnibus model of incentives for human capital investment? (Yes, draw a diagram)

2.2 Evidence for a tenure effect on wages

- See column (1) of Tables 4a and 4b of Abraham and Farber (AER, 1987).
- The OLS estimated return to experience is 3.5 log points, and the OLS return to tenure (net of experience) is an additional 1.1 log points. If this latter point estimate is causal and half of the tenure return is shared between workers and firms, then the true value of specific capital investment is 2.2 log points, or two thirds at large as the value of general human capital accumulation. That's big!
- The 'tenure effect' was historically been interpreted as evidence of accumulation of firm 'specific human capital.' What is the source of identification for these comparisons? Comparison of endogenous stayers versus endogenous movers.
- Possible interpretations of the 'tenure effect:'
  1. Return on specific human capital
  2. High wage jobs last longer – so there will be composition bias in cross-sectional estimates
  3. More able workers tend to keep their jobs longer – also will yield composition bias
- What are the testable implications of these three views:
  1. Return on specific human capital: High tenure workers who are exogenously separated from their current employer will have earnings losses.
  2. High tenure workers who are exogenously separated from their current employer will have earnings losses. BUT these jobs were high wage at the start. So even low tenure workers would also have substantial job losses.
  3. More able workers tend to keep their jobs longer. No earnings loss in this case – it's a return to ability.

- How have economists attempted to sort this out?

2.3 Abraham and Farber (1987)

- This was quite an influential paper.

- It might also helpfully remind you – or inform you if you never knew – how economists were thinking about identification and IV problems prior to the current era of transparency. It's all about epsilons and correlations among disturbances rather than anything about exogenous variation. By the standards of its day, this paper was at the frontier.

- Abraham and Farber want to tackle the composition bias problem posited above: high wage jobs last longer and so the returns to tenure from an OLS will be averaging over short-low-wage jobs and long-high-wage jobs. This will make it appear that longer tenure gives rise to high wages, when if we could look back in time, we would find that the high tenure jobs were high wage from the get-go.

- It seems that one could actually investigate this implication directly using panel data: taking the cross-section of job spells originating in period t, is the case that those jobs unexpectedly high wages in t have a greater probability of lasting to $t+1$? But this is not their approach.

- They note that:

  - In the cross-section, we should be observing workers at the mid-point of their current employment spells.

  - So, if we had data on the starting point of jobs, we could predict their eventual completed length using their length up to the present. In other words, we could instrument for eventual length using current length. [Note the distinction between maximum likelihood and frequentist estimation here...]

  - Then, we could control for predicted completed length in a regression of wages on experience and tenure.

- The composition bias hypothesis would predict that eventual length rather than current length would explain high wages in high tenure jobs.
- Better still, if we knew ultimate length, we could control for that directly.
- In fact, AF do a combination of the two since they have completed spell length in their data for a majority of jobs.

- Incidentally, when they run the current tenure S as a function of completed tenure D, they obtain

$$S_{ijt} = \underset{(.18)}{-2.24+} \quad \underset{(.007)}{0.534 \cdot D_j} \qquad R^2 = 0.61 \; ,$$

so the expectation is generally right but statistically far from perfect. In fact, current spells are more than 1/2 way complete on average.

- Their main results are seen in Tables 4a and 4b. Once they control for expected or actual completed tenure, the contemporaneous return to tenure is essentially zero (positive for white collar, infinitesimal for blue collar).

- The ReStud paper by Altonji and Shakotko (1987) does something similar in spirit and reaches a similar conclusion.

2.4 Topel, 1991, JPE

- In reading these papers, one wonders if their IV strategies are 'biased' by design in the direction of attributing wage growth to things other than tenure. In general, instrumenting one covariate will affect the estimates of other covariates if there is correlated measurement error. If final tenure is purged of measurement error by the IV strategy but contemporaneous tenure is not, it's plausible that much of the wage variation will load on the better measured variable, i.e., final rather than current tenure. If we overestimate the return to final tenure, we have to underestimate the return to current tenure.

- For neither the first nor last time in his career, Robert Topel rides in on the *JPE* to rescue the neoclassical model. In this case, the title says it all: "Wages Rise with Job Seniority."

- Table 1 of Topel's paper has a major intraocular impact. Of our three explanations for the empirical link between tenure and earnings

  - return on specific human capital;
  - high wage jobs last longer;
  - more able workers tend to keep their jobs longer,

  ...only the first two now appear appear plausible. The earnings loss associated with job loss is strongly increasing in seniority. So this cannot just be heterogeneity in skill that is carried from job to job.

- [One question not answered: Is Topel somehow imputing a low log earning number for workers who have not yet found reemployment? This would substantially change the interpretation.]

- Topel's idea:

  1. Let's look at real wage growth within jobs.
  2. With some further assumptions, this growth can be interpreted as a convex combination of returns to experience and returns to tenure.
  3. Now, attempt a decomposition to find a lower bound on the share of this growth that is explained by tenure.

- Write the model

$$y_{ijt} = \beta_1 Exp_{ijt} + \beta_2 Tenure_{ijt} + \varepsilon_{ijt}. \tag{1}$$

- Rewrite the error term as

$$\varepsilon_{ijt} = \phi_{ijt} + \mu_i + \nu_{jt},$$

  μ is not a major concern since a person specific effect can be differenced away. ν is also not a concern if it's a market wide phenomenon – we can get it with time effects.

- The main concern for identification is that ϕ_{ijt} is some measure of 'match quality' that is correlated with Exp and $Tenure$. Specifically, write the auxiliary regression

$$\phi_{ijt} = b_1 Exp_{ijt} + b_2 Tenure_{ijt} + \upsilon_{ijt}. \tag{2}$$

OLS estimates of (1) will yield $E\hat{\beta}_1 = \beta_1 + b_1$, $E\hat{\beta}_2 = \beta_2 + b_2$. So, if high tenure jobs are due to better matches – i.e., higher wages from the outset – then $\hat{\beta}_2$ will be biased upward.

- Topel has an extensive discussion rooted in search theory of whether we should in fact expect that $b_2 > 0$. He makes the points that:

  - Given stochastic arrival, good job offers will cumulate with labor market experience.
  - If tenure really does increase earnings ($\beta_2 > 0$ in (1)) then workers will only switch to jobs that compensate them for foregone returns to tenure (i.e., when a new job with, by definition, zero tenure but high ϕ come along).
  - In this case, the OLS returns to tenure will be biased downward. Why? The tenure coefficient in a wage regression compares movers to stayers:

    * Stayers: Some workers who would have left due to the arrival of a higher ϕ will stay due to β_2, meaning that observed within-job wage growth among stayers is dampened relative to movers. We don't get to see their actual loss of the wage benefits of tenure because they don't move.
    * Movers: Those who *do* move will only do so in response to really good wage offers. This will raise the estimated return to experience instead of the return to tenure.
    * Hence, by both arguments, $E(y|X, T+1) - E(y|X, T) < \beta_2$. This is clever.

- Implementation of the 2 stage estimator: We observe that

$$y_{ijt} - y_{ijt-1} = \beta_1 + \beta_2 + \varepsilon_{ijt} - \varepsilon_{ijt-1}. \tag{3}$$

Notice that this β_1, β_2 are not separately identified in a standard regression – just their sum – since Exp and $Tenure$ increase by the same amount in each year ($\Delta EXP = \Delta TENURE = 1$ in each year).

- If we had an extraneous, unbiased estimate of $\tilde{\beta}_1$, the return to experience, then we could calculate $\tilde{\beta}_2 = (\beta_1 + \beta_2) - \tilde{\beta}_1$.

- Topel proposes to use the estimated return to prior experience *at the start of a job* as an estimator of $\tilde{\beta}_1$. So
$$y^0_{ijt} = \tilde{\beta}_1 X^0_{ijt} + \omega_{ijt}.$$
This estimator may not be entirely free of bias due to matching considerations, but by the arguments above, it will *overstate* the return to experience if $\beta_2 > 0$. Hence, $\tilde{\beta}_2 = (\beta_1 + \beta_2) - \tilde{\beta}_1$ should put a lower bound on the return to tenure.

- So, this is pretty much rabbit-out-of-a-hat kind of technique. You didn't see it coming, but once the rabbit is there, it seems real enough.

- Without belaboring the details, Table 2 gives estimates of the combined $\beta_1 + \beta_2$ from equation (3) .

- Applying estimates of $\tilde{\beta}_1$ to the Table 2 results yields Table 3, which shows very large returns to tenure indeed. In fact, they are on the same order of the Table 1 results – which implies (under this model) that there is little bias in the cross-sectional returns to tenure.

- Much more follows, but it doesn't change this basic story.

- This is an impressive paper, well worth understanding from an econometric standpoint. There is lots of sensible, well exposited technique in this paper, and you would be wise to spend some time mastering it.

- Topel also carefully replicates and critiques both Altonji and Shakotko and Abraham and Farber. This is what good labor economists are supposed to do. This paper represents the best of a labor tradition that is less commonplace now than 10 years ago. A shame.

2.5 Jacobson, LaLonde and Sullivan (AER, 1993)

- But to many economists, Topel's paper would appear too clever by half. It is clearly devastating to its competition. But to many skeptics, no amount of savvy econometric manipulation is going to stand in for a good experiment.

- Jacobson, LaLande and Sullivan's 1993 AER paper finds this experiment. They explore the value of specific capital with data on job losses for high tenure workers from distressed firms in Pennsylvania in the 1980s.

- This paper is quite far ahead of its time. The techniques used are very familiar to contemporary labor economists – so much so that I won't really discuss them – but that was not true in 1993. You should be certain you understand everything they are doing.

- JLS Figure 1

- Key findings:

  - Displaced workers relative earnings begin to decline almost 3 years prior to job loss
  - They drop by almost 50% in quarter of loss
  - Rise rapidly over 6 quarters
  - Then level out at 25% below pre-displacement earnings

- Huge, clear cut.

- Critiques. (See Table 2: Primary metals).

2.6 The Lazaer critique of the concept of 'specific capital.'

- Could specific capital plausibly be as important to earnings growth as is experience? (Remember that returns are shared between worker and firm – implying that OLS returns to tenure understate the productivity of specific capital).

- An alternative interpretation: 'Market thickness.' Specific capital as a case of the thinnest possible market – one buyer.

- Worker has a vector of skills, not all of which are equally productive at every firm.
- Think of wage as inner product of worker's skills and firm's weights on those skills.
- Then the 'tenure' effect is a function of:
  - Difference between value that incumbent and new firm places on these skills
  - This in turn affected by worker's investment decisions among skills
  - A function itself of probability of job separation
  - And distribution of weights at other firms

2.7 Small model (Lazaer)

- 2 periods, 2 skills
- Workers invest in period 1, receive returns in period 2
- Two skills A and B that worker can acquire at cost $C(A, B)$.
- Worker with skill set $\{A, B\}$ has potential earnings at firm i of

$$y_i = \lambda_i A + (1 - \lambda_i)B,$$

  where $\lambda_i \in [0, 1]$.
- Let probability of staying into period 2 be ρ.
- Let density of λ be $f(\lambda)$.
- Worker employed at firm 1 chooses A, B to maximize

$$\max_{A,B} = \rho [\lambda_1 A + (1 - \lambda_1)B] + (1 - \rho) \int_0^1 [\lambda A + (1 - \lambda)B] f(\lambda) \, d\lambda - C(A, B),$$

  with FOCs

$$\begin{aligned} \rho\lambda_1 + (1 - \rho)\bar{\lambda} - C_A &= 0, \\ \rho(1 - \lambda_1) + (1 - \rho)\left(1 - \bar{\lambda}\right) - C_B &= 0. \end{aligned}$$

- Let A^*, B^* solve this problem. Investment is a weighted average of relevant skill-weights inside firm and outside, where weights depend on probability of separation and distribution of outside opportunities. Notice that if $\rho = 1$, investment only depends on λ_1.

- Can calculate a stylized 'tenure effect.'

- Wages in period 1 are assumed 0.

- Wages of stayers are

$$y_1 = \lambda_1 A^* + (1 - \lambda_1) B^*.$$

- Wages of leavers are

$$y_2 = \lambda_2 A^* + (1 - \lambda_2) B^*.$$

- Tenure coefficient is that part of wage growth that is not common to stayers and leavers:

$$\begin{aligned} \Delta &= \lambda_1 A^* + (1 - \lambda_1) B^* - \lambda_2 A^* - (1 - \lambda_2) B^* \\ &= (\lambda_1 - \lambda_2)(A^* - B^*). \end{aligned}$$

- So, tenure effect is

$$E(\Delta) = E\left[(\lambda_1 - \lambda_2)(A^* - B^*)\right].$$

- Experience effect is what stayers and leavers have in common, which is the wage of stayers minus the tenure effect

$$\begin{aligned} \text{Exp Effect} &= E\left[\lambda_1 A^* + (1 - \lambda_1) B^* - (\lambda_1 - \lambda_2)(A^* - B^*)\right] \\ &= E\left[\lambda_2 A^* + (1 - \lambda_2) B^*\right]. \end{aligned}$$

- Some intuitive comparative statics:

  1. Is tenure effect always positive? No, but usually. Why? Because investment is directed towards period 1 firm.

  2. If probability of staying ρ larger, investment more idiosyncractic, losses greater in expectation

3. Market thickness has 2 effects:
   - Less expected loss conditional on given skills
   - Little trade-off between investing in own firm and market
   - These are complementary – interesting

- Who pays for training? Lazaer asserts that under skill weights approach, firms in a thin market have incentive to pay for skills training – because worker will almost surely lose by leaving.

- Is this correct? I'd say yes. So long as $E(\Delta) = E[(\lambda_1 - \lambda_2)(A^* - B^*)] > 0$, firm has incentive to increase A, B.

- A number of other implications are stated very loosely. Do these follow?

1. "Market Thickness: The implications of market thickness distinguish between the two theories. In the skill-weights approach, tenure effects should be smaller in thick markets than in thin markets. No such implication comes from the traditional view."
2. "Firm Size: When a worker leaves a large firm, tenure effects should be large. When a worker joins a large firm, tenure effects should be smaller. If large firms have lower turnover rates and can better cater to a worker's endowed skills, then workers from large firms are likely to be less diversified in their choice of skills than those from small firms. Thus, departures from large firms should result in larger wage losses. Conversely, when a worker joins a large firm, there is a better chance that the worker will find a job that suits his pattern of prior investment because within the firm there is a larger range of specialization. This is not an implication of the traditional view of firm-specific human capital."
3. "Idiosyncratic Firms: The more idiosyncratic is a firm's skill-weights, the larger is the loss associated with a move. New and unusual technologies, even though general in the traditional sense, probably have more idiosyncratic weights. As a result, tenure effects should be

4. larger in new and unusual industries. Newness is straightforward to measure, but it may be more difficult to obtain empirical analogues of "unusualness" in the sense that few firms attach significant weight to the skill required at the initial firm."

Abraham & Farber
AER 77:3, 1987

TABLE 4a—SELECTED COEFFICIENTS FROM ln (AVERAGE HOURLY EARNINGS) MODELS
MANAGERIAL AND PROFESSIONAL NONUNION SAMPLE[a]

	Mean [s.d.]	OLS (1)	IV (2)	OLS (3)	OLS (4)
Years of Experience	18.14 [10.08]	.0349 (.0027)	.0392 (.0058)	.0288 (.0027)	.0263 (.0031)
(Years of Experience)^2	430.77 [407.84]	−.00062 (.00006)	−.00077 (.00014)	−.00048 (.00007)	−.00043 (.00007)
Years of Current Seniority	8.88 [8.34]	.0106 (.0011)	.00585 (.00128)	.00548 (.00178)	.00520 (.00256)
E(Completed Job Duration)	20.83 [12.18]	–	–	.0198 (.0024)	.0265 (.0050)
$\{E$(Completed Job Duration)$\}^2$	631.55 [505.56]	–	–	−.00035 (.00006)	−.00059 (.00016)
E(Job Duration) $\times[=1$ if $3 < \text{Seniority} \leq 10]$	6.02 [10.46]	–	–	–	−.00094 (.00432)
$\{E$(Job Duration)$\}^2$ $\times[=1$ if $3 < \text{Seniority} \leq 10]$	165.4 [325.3]	–	–	–	.00009 (.00015)
E(Job Duration) $\times[=1$ if Seniority $> 10]$	11.09 [15.78]	–	–	–	−.00798 (.00455)
$\{E$(Job Duration)$\}^2$ $\times[=1$ if Seniority $> 10]$	380.1 [572.9]	–	–	–	.00030 (.00015)
R^2	–	.3696	.3575	.3871	.3883

[a]All models also include controls for education, race, marital status, disability, occupation, industry, region, and year. E (Completed Job Duration) is computed using the estimates in col. 1 of Table 2. The numbers shown in parentheses are standard errors. Sample size = 3493.

Abraham & Farber
AER, v 77:3, 1987

TABLE 4b—SELECTED COEFFICIENTS FROM ln (AVERAGE HOURLY EARNINGS) MODELS
BLUE-COLLAR NONUNION SAMPLE[a]

	Mean [s.d.]	OLS (1)	IV (2)	OLS (3)	OLS (4)
Years of Experience	17.34	.0205	.0173	.0117	.0120
	[11.14]	(.0024)	(.0040)	(.0026)	(.0026)
(Years of Experience)^2	424.70	−.00045	−.00042	−.00026	−.00028
	[470.81]	(.00006)	(.00009)	(.00006)	(.00006)
Years of Current Seniority	6.31	.0142	.00290	.00241	−.00054
	[7.46]	(.0011)	(.00172)	(.00213)	(.00302)
E(Completed Job Duration)	13.86	–	–	.0154	.0381
	[11.75]			(.0021)	(.0057)
{E(Completed Job Duration)}^{2}	362.44	–	–	−.00014	−.00104
	[444.45]			(.00006)	(.00024)
E(Job Duration) ×[=1 if 3 < Seniority ≤ 10]	4.57	–	–	–	−.00592
	[8.27]				(.00538)
{E(Job Duration)}^{2} ×[=1 if 3 < Seniority ≤ 10]	102.13	–	–	–	.00031
	[211.7]				(.00024)
E(Job Duration) ×[=1 if Seniority > 10]	6.45	–	–	–	−.0241
	[12.90]				(.0055)
{E(Job Duration)}^{2} ×[=1 if Seniority > 10]	215.1	–	–	–	.00103
	[461.9]				(.00024)
R^2	–	.3878	.3513	.4041	.4098

[a]All models also include the controls listed in Table 4a, fn. a. E (Completed Job Duration) is computed using col. 2, Table 2. Standard errors are shown in parentheses. Sample size = 3554.

R. Topel, JPE
99:1, 1999

TABLE 1

WAGE CHANGES OF DISPLACED WORKERS BY YEARS OF PRIOR JOB SENIORITY, JANUARY CPS, 1984 AND 1986

	Years of Seniority on Prior Job				
	0–5	6–10	11–20	21+	Total
Average change in log weekly wage	−.095	−.223	−.282	−.439	−.135
	(.010)	(.021)	(.026)	(.071)	(.009)
Percentage displaced by plant closing	.352	.463	.528	.750	.390
	(.008)	(.021)	(.026)	(.043)	(.007)
Weeks unemployed since displacement	18.69	24.54	26.66	31.79	20.41
	(.413)	(1.202)	(1.536)	(3.288)	(.385)

NOTE.—Estimates refer to male respondents between the ages of 20 and 60. Sample size is 4,367. Nominal data are deflated by the GNP price deflator for consumption expenditure. Figures in parentheses are standard errors.

R. Topel, JPE 99:1, 1999

TABLE 2

MODELS OF ANNUAL WITHIN-JOB WAGE GROWTH, PSID WHITE MALES, 1968–83
(Dependent Variable Is Change in Log Real Wage; Mean = .026)

	Model (1)	Model (2)	Model (3)
Δ Tenure	.1242	.1265	.1258
	(.0161)	(.0162)	(.0162)
Δ Tenure^2 (× 10^2)	...	−.0518	−.4592
		(.0178)	(.1080)
Δ Tenure^3 (× 10^3)	...	...	.1846
			(.0526)
Δ Tenure^4 (× 10^4)	...	...	−.0245
			(.0079)
Δ Experience^2 (× 10^2)	−.6051	−.6144	−.4067
	(.1430)	(.1430)	(.1546)
Δ Experience^3 (× 10^3)	.1460	.1620	.0989
	(.0482)	(.0485)	(.0517)
Δ Experience^4 (× 10^4)	.0131	.0151	.0089
	(.0054)	(.0055)	(.0058)
R^2	.022	.023	.025
Standard error	.218	.218	.218

PREDICTED WITHIN-JOB WAGE GROWTH BY YEARS OF JOB TENURE
(Workers with 10 Years of Labor Market Experience)

	Tenure 1	2	3	4	5	6	7	8	9	10
Predicted wage growth (%)	.068	.060	.052	.046	.041	.037	.033	.030	.028	.026

NOTE.—Estimates are based on within-job first differences of log average hourly earnings. Standard errors are in parentheses. Number of observations is 8,683

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TABLE 3

Second-Step Estimated Main Effects of Experience (β_1) and Tenure (β_2) on Log Real Wages, and Least-Squares Bias in Wage Growth ($b_1 + b_2$)

	Experience Effect, β_1 (1)	Within-Job Wage Growth, $\beta_1 + \beta_2$ (2)	Tenure Effect, β_2 (3)	Wage Growth Bias, $b_1 + b_2$ (4)
Main effect	.0713	.1258	.0545	.0020
	(.0181)	(.0161)	(.0079)	(.0004)
Estimated Cumulative Return to Job Tenure				
	5 Years	10 Years	15 Years	20 Years
Two-step model	.1793	.2459	.2832	.3375
	(.0235)	(.0341)	(.0411)	(.0438)
OLS	.2313	.3002	.3203	.3563
	(.0098)	(.0105)	(.0110)	(.0116)

Note.—Estimated within-job wage growth ($\beta_1 + \beta_2$) from table 2, col. 3. Dependent variable for other estimates is log real hourly earnings less the effects of variables that are consistently estimated from the within-job wage growth model. Other regressors in the second-step model (10) include years of completed schooling, marital status, residence in an SMSA, current disability, union membership, and eight indicators for census region of residence. Estimated cumulative returns are based on the main effect of job tenure ($\beta_2 = .0545$) plus the effects of higher-order terms in tenure shown in col. 3 of table 2. Standard errors (in parentheses) are corrected to reflect sampling error in the first-step estimates. Methods developed in Murphy and Topel (1985) are used for this Number of observations is 10,685

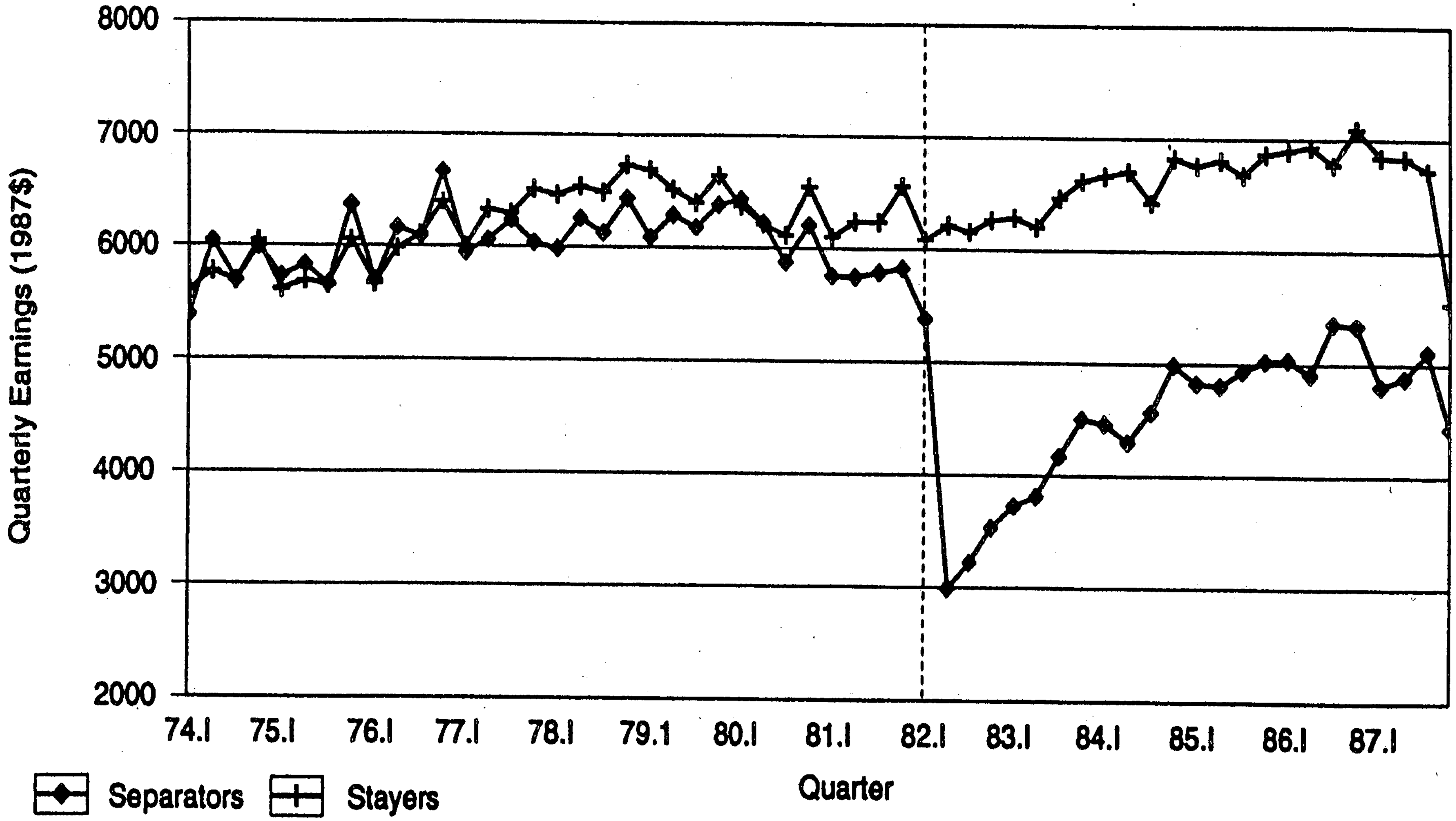

FIGURE 1. QUARTERLY EARNINGS (1987 DOLLARS) OF HIGH-ATTACHMENT WORKERS SEPARATING IN QUARTER 1982:1 AND WORKERS STAYING THROUGH QUARTER 1986:4

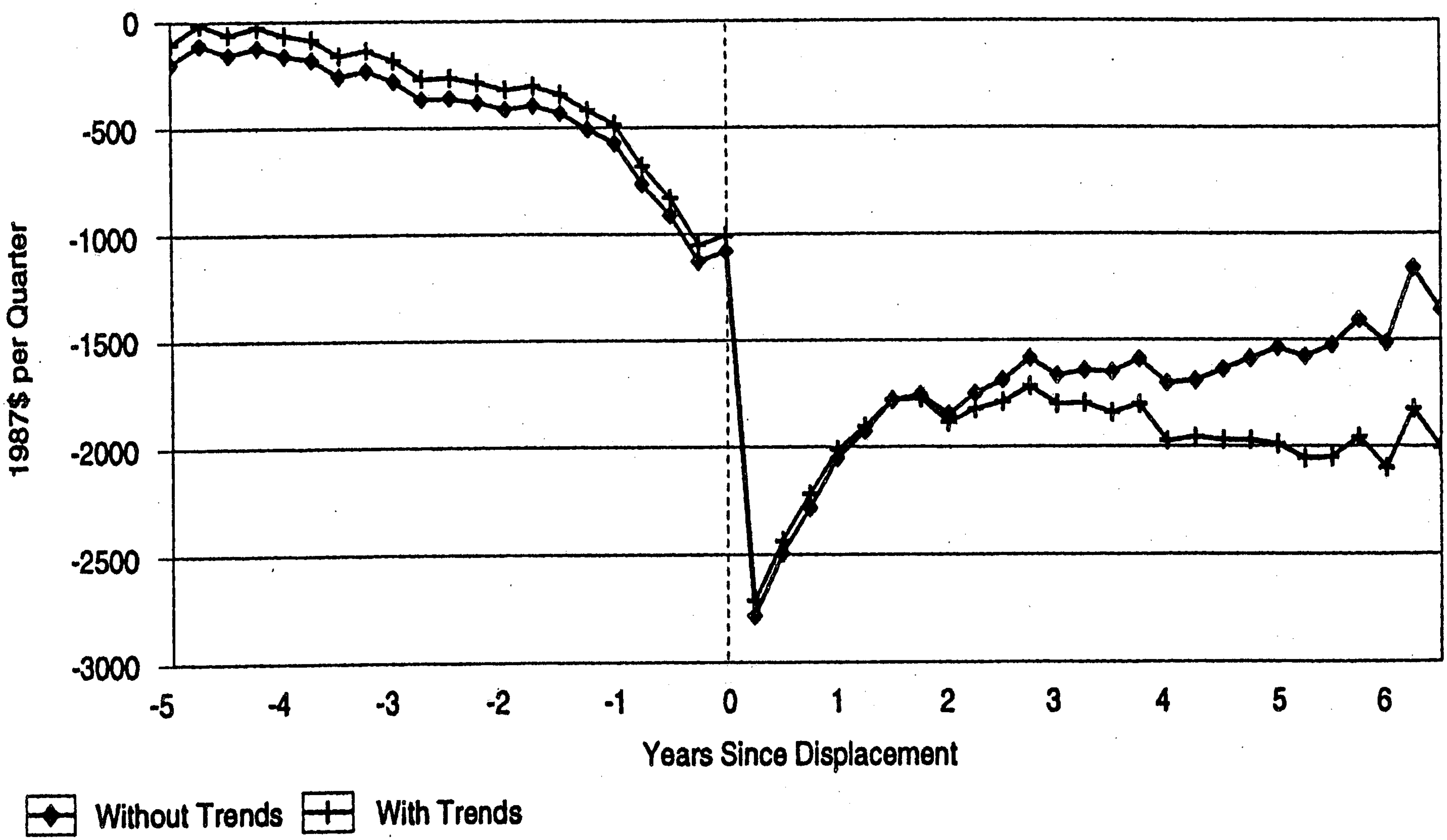

FIGURE 2. EARNINGS LOSSES FOR SEPARATORS IN MASS-LAYOFF SAMPLE

TABLE 2—LOSSES BY WORKER CHARACTERISTICS

Group	Number	Without other controls[a]					With other controls[b]				
		Dip[c]	Drop[d]	Recovery[e]	Fifth-year loss dif	Fifth-year loss	Dip	Drop	Recovery	Fifth-year loss dif	Fifth-year loss
Overall	6,435						–83.3	–2,179	15.4	—	–6,611
							(2.2)	(16)	(4.4)		(150)
Sex:											
Male	4,972	–10.8	–217	6.5	–545	–7,143	–3.4	–103	4.7	–177	–6,788
		(0.7)	(7)	(0.9)	(40)	(132)	(0.7)	(7)	(0.9)	(43)	(157)
Female	1,463	36.7	738	–22.0	1,853	–4,744	11.6	350	–16.0	602	–6,009
		(2.2)	(24)	(3.0)	(136)	(184)	(2.3)	(25)	(3.2)	(145)	(207)
Decade of birth:											
1930's	2,599	–0.0	116	–10.9	–79	–6,677	–0.3	55	–10.1	–284	–6,896
		(1.4)	(16)	(2.0)	(92)	(159)	(1.4)	(16)	(2.1)	(94)	(182)
1940's	2,584	7.2	3	4.6	241	–6,356	3.6	–28	5.6	171	–6,440
		(1.4)	(15)	(2.0)	(87)	(151)	(1.4)	(15)	(2.0)	(88)	(172)
1950's	1,252	–14.9	–247	13.1	–333	–6,932	–6.9	–58	9.4	238	–6,374
		(2.4)	(25)	(3.2)	(144)	(188)	(2.4)	(25)	(3.2)	(145)	(203)
Industry:											
Mining and construction	247	1.3	–497	7.5	–1,616	–8,435	9.5	–387	–0.1	–1,549	–8,160
		(5.6)	(58)	(7.6)	(332)	(352)	(5.8)	(59)	(7.8)	(339)	(369)
Nondurable manufacturing	1,206	26.5	624	–14.6	1,766	–5,052	18.3	338	–7.7	967	–5,644
		(2.3)	(25)	(3.3)	(144)	(188)	(2.6)	(28)	(3.7)	(160)	(224)
Primary metals	1,354	–121.2	–1,991	54.1	–5,256	–12,074	–104.5	–1,476	40.5	–3,878	–10,489
		(2.2)	(24)	(3.6)	(157)	(210)	(2.7)	(30)	(4.4)	(191)	(241)
Fabricated metals	436	21.0	611	–11.2	1,882	–4,936	15.9	488	–9.8	1,465	–5,146
		(4.2)	(44)	(6.4)	(274)	(301)	(4.2)	(45)	(6.5)	(279)	(312)
Nonelectrical machinery	632	47.9	1,005	–36.9	2,174	–4,644	35	797	–27.4	1,817	–4,794
		(3.4)	(38)	(5.8)	(249)	(284)	(3.5)	(39)	(5.9)	(257)	(306)
Electrical machinery	421	43.2	288	7.0	1,500	–5,318	49.5	494	–2.7	1,842	–4,769
		(4.2)	(46)	(6.1)	(270)	(300)	(4.3)	(47)	(6.4)	(282)	(322)
Transportation equipment	419	25.0	422	–27.5	310	–6,508	14.1	215	–15.5	85	–6,526
		(4.3)	(46)	(6.2)	(264)	(291)	(4.4)	(48)	(6.6)	(282)	(324)
Other durable manufacturing	441	25.6	525	3.0	2,248	–4,570	18.9	338	9.1	1,807	–4,804
		(4.2)	(43)	(5.5)	(237)	(262)	(4.2)	(43)	(5.7)	(242)	(282)
Transportation, communication, and public utilities	348	6.6	150	–63.5	–2,573	–9,392	5.5	66	–63.6	–2,916	–9,527
		(4.7)	(49)	(7.0)	(295)	(321)	(4.8)	(50)	(7.1)	(301)	(333)
Wholesale and retail trade	545	18.7	198	2.0	891	–5,927	20.0	126	4.8	745	–5,866
		(3.7)	(38)	(4.8)	(207)	(235)	(3.8)	(38)	(4.9)	(211)	(251)
Finance, insurance, and real estate	183	127.7	1,312	14.3	5,963	–855	115.7	947	24.3	5,004	–1,608
		(6.6)	(70)	(8.2)	(352)	(369)	(6.7)	(72)	(8.3)	(358)	(387)
Professional, business, and entertainment services	203	82.0	1,158	–18.2	3,725	–3,093	93.1	1,270	–26.2	3,769	–2,843
		(6.3)	(63)	(8.4)	(360)	(378)	(6.4)	(64)	(8.7)	(369)	(394)
Firm size:											
50–500	1,704	7.9	351	0.6	1,434	–5,403	–16.1	–37	13.0	501	–6,110
		(1.9)	(20)	(2.6)	(113)	(163)	(2.1)	(22)	(2.9)	(124)	(193)
501–2,000	1,497	33.5	501	–14.1	1,298	–5,540	13.9	214	–4.7	625	–5,986
		(2.0)	(22)	(2.9)	(127)	(176)	(2.2)	(23)	(3.1)	(135)	(246)
2,001–5,000	1,381	40.9	720	–32.3	1,267	–5,570	27.2	480	–23.8	730	–5,881
		(2.2)	(23)	(3.1)	(134)	(179)	(2.3)	(24)	(3.5)	(149)	(203)
Greater than 5,000	1,853	–64.8	–1,265	34.9	–3,312	–10.150	–16.7	–497	9.6	–1,510	–8,121
		(1.8)	(19)	(2.9)	(125)	(190)	(2.3)	(25)	(3.6)	(154)	(224)